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UPPER CARBONIFEROUS

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VI

The Upper Carboniferous, rather in contrast with the Lower, was a period of emergence of shores and of shallowed waters, and it presents the variety that appertains to such conditions. In considering the stratigraphic relations of the Pennsylvanian and Permian one cannot fail to be struck by the local character of the phenomena, and the vast amount of detail, from which it is difficult to disengage facts of broader significance. One of the facts of larger moment is the general unconformity which occurs at the base of the Pennsylvanian rocks. The extent of the phenomenon may be gauged by this: that an unconformity probably occurs at this horizon all the way from Pennsylvania to the Mexican boundary, except possibly in the deeper troughs. The underlying strata range in age from pre-Cambrian to Upper Mississippian. This is evidently, therefore, an unconformity by overlap, but the overlap is sometimes not appreciable unless extensive areas be kept in view. Very rarely, I believe, is any angular unconformity to be observed, but there are basal conglomerates and in many places unmistakable evidence of erosion in the subjacent strata. Some of the most noteworthy instances of erosion are to be found in Missouri where shales of Pennsylvania age were deposited in sink holes and subterranean channels in the

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[1] Read before Section E of the American Association for the Advancement of Science, at the Baltimore Meeting, December, 1908.

Lower Mississippian limestones. On the other hand, evidences of erosion are often wanting and sometimes any physical suggestion of an interruption in sedimentation. A striking instance of this sort occurs in southern Arizona. In the Bisbee area limestones of Pennsylvanian age rest upon limestones of Lower Mississippian age, the two series being extremely similar in physical characters, though carrying different faunas. The same condition probably exists in the Redwall limestone of the Grand Canyon region, whose lower part is of lower Mississippian age and whose upper has furnished, according to Meek, a long list of Pennsylvanian species. The presence of this unconformity is to be detected therefore not always by local evidences of erosion or changes in sedimentation, but sometimes only by paleontologic evidence in the abrupt and great change in the faunas and floras, and by stratigraphic evidence in the overlap, sometimes appreciable only by considering rather wide areas.

Inasmuch as we find this extensive area in which a hiatus exists at the base of the Pennsylvanian, and inasmuch as over part of the area unmistakable evidence of erosion is found, the inference is probably a safe one that everywhere within this region the hiatus is partially at least due to post-Mississippian erosion.

The presence of this erosion period implies the existence of a land surface over the eroded area, for the alternative hypothesis of submarine erosion may probably be disregarded.

The boundaries of the land cannot be exactly defined. On the east I would judge that it must have followed a presumably irregular line southwestward from northern Pennsylvania to southwestern Texas. At least, there is a well marked unconformity west of such a line, while in some sections east of it, sedimentation appears to have been continuous from the Mississippian into the Pennsylvanian. An estimate of where the boundary lay on the western side is conditioned somewhat by our correlations of the western Mississippian faunas with the eastern and with one another, especially as to areas over which the Upper Mississippian is wanting.

It is pretty well established by many observations that faunas with a Kaskaskian facies are not known west of the Mississippi Valley. There are, however, some faunas peculiar to the West which may be of Kaskaskian age. The best known and most notable of these occurs in the Baird shale of California, and has not been found elsewhere on the continent. It is characterized among other things by the European *Productus giganteus*, and can be correlated more easily with the Mountain limestone of Europe than with our own Mississippian.

Although the *Productus giganteus* fauna strictly speaking is, so far as we know, restricted to California, there is another western fauna having a different facies which I am inclined to correlate with it. It comprises little besides corals, chiefly large Cyathophylloids. I have noted it in Utah, Montana, and Idaho. We have some reason to believe that it represents the Upper Mississippian to the East and the Baird fauna to the West. If this is so, the evidence upon which we chiefly relied for recognizing post-Mississippian erosion—the absence of the Upper Mississippian—is lacking over this area and the hypothetical land mass would appear to have extended westward on its northern margin no farther than western Montana and central Utah.

As to what were probably the northern and southern boundaries, evidence is wanting, Carboniferous strata being absent in Canada across its trend and absent or concealed by Cretaceous overlap in Mexico except just over the Texas border in the state of Chihuahua.

The unconformity of which I have just been speaking occurs at the base of the Upper Carboniferous. There is, however, a second important unconformity which occurs in the middle of the Upper Carboniferous and is less widespread as to the area in which it has been recognized. Like the other, it is marked rather by overlap than by discordance. The overlap is most conspicuous in western Texas and New Mexico, but equivalent strata, distinguished from the preceding ones by a distinct faunal change, and in some cases by basal conglomerates, probably extend into Arizona and Nevada, or even farther.

Lithologically the beds of the Upper Carboniferous and Permian present the greatest variety, and about the only truth of broad applicability has long been known. I mean that in eastern North America the sediments of the Upper Carboniferous are chiefly shales, sandstones and conglomerates with some thin limestones, while in the West the limestones have a much larger development, and coals, which toward the East play so important a part, if not in thickness at least economically and significantly in the Carboniferous sediments, are there practically absent. From this it has been justly inferred that the character of the eastern Carboniferous indicates shore and estuarine conditions of deposition, while that of the western indicates marine conditions of deposition. There are, however, vast amounts of sandstone and shale in the Upper Carboniferous of the West.

It seems to be true that the greatest deposits of limestone in this series are found rather to the Southwest than to the West and the most notable thicknesses of sandstone and conglomerate rather to the Northeast than to the East.

There is one other phenomenon of more than local interest which should not be omitted in a commentary on the lithologic features of the Upper Carboniferous. I refer to the red beds of the West and Southwest. The age, the stratigraphic relations, the sources, and the cause of the peculiar coloration of this great series of sandstones and conglomerates form a problem of no mean difficulty and importance. Although it is difficult to trace these beds stratigraphically, and though fossils are rarely found in them, we know now that sediments of this character were formed rather early in the Pennsylvania and successive manifestations recurred at various periods on into the post-Cretaceous. That there were continuous red beds conditions during all this period seems out of the question, and also that red beds conditions repeatedly recurred. Some of the occurrences can probably be best explained as a reworking of older materials under conditions unlike those which determined their original character.

In considering the faunas of the later Paleozoic—those of the Pennsylvanian and Permian—several facts of a general nature can be stated. The Upper Carboniferous faunas of western North America have a facies markedly different from those of the eastern part and are closely comparable to the corresponding faunas of Asia and eastern Europe. A second fact of general import seems to be that, quite in contrast to the unstable physical conditions in which they lived, these eastern faunas, which range, let us say, westward to the Rocky Mountains, are remarkably uniform both in their geographic distribution and in their range. I would be far from saying that the

Upper Carboniferous faunas of the continental basin do not show differentiation during this long interval, for the Pottsville group has a distinct fauna and appreciable changes occur in the later Pennsylvanian. But the changes are by no means so marked as one would be led to expect from the thickness of the strata involved, the extent of the territory they cover, and the varying conditions of the time and the place. The truth of this statement will be appreciated upon a consideration of the Mississippian series of the Upper Mississippi Valley and the subdivisions which have been established in it.

When we speak of the variety of conditions under which the sediments in question were laid down, and remember that they include the great coal deposits of this era, we are led to inquire whether the faunas are marine or fresh water, or perhaps both, with the important difference in facies which such difference in habitat would doubtless entail. Fresh-water faunas, or at least fresh-water genera and species, have been recognized elsewhere in the Carboniferous, notably in the Coal Measures of England and the Permian of Russia. In North America, although we have a facies which appears to be non-marine, there are no Carboniferous faunas which in my belief can be called fresh water. The facies in question recurs frequently, particularly in the Appalachian region, and manifests little change in its general aspect, although appearing at widely different horizons in the Pennsylvanian. It is very restricted in variety though often abounding in individuals. A mollusk probably identifiable as *Naiadites elongatus* Dawson is a characteristic feature. Ostracods are also abundant, and the large bivalve Crustaceans, *Estheria* and *Leaia*, sometimes occur. *Spirorbis* is another type frequently met with, while fish scales, fragments of *Limuloid* Crustaceans, and wings of insects are rare. Usually this peculiar assemblage of forms is associated with abundant coal plants.

The genus *Naiadites* was described by Dawson from the Nova Scotia Coal Measures, in which it occurs with a fauna similar to that sketched above. Dawson regarded the sediments and faunas as representing fresh-water conditions, and considered *Naiadites* to be related to the Naiads of our fresh-water lakes and rivers.

The fresh-water mollusks of the English Carboniferous were included by Dr. Wheelton Hind under the three genera, *Anthracoptera*, *Anthracomya*, and *Anthrocosia* in a valuable monograph published a few years ago. Later, after studying specimens of *Naiadites* from Nova Scotia, he reached the conclusion that *Anthracoptera* and *Naiadites* were the same genus.

Thus far the balance of evidence and opinion seems to be in favor of the fresh-water habitat of the fauna. On the other hand, externally and internally, *Naiadites* is extremely like the marine genus *Myalina*, and Dr. Hind has referred many of our marine *Myalinas* to *Naiadites*. In fact, he has even placed the names of some of our American *Myalinas* which always occur associated with marine faunas in the synonymy of English species of *Naiadites* which are supposed to be strictly fresh water. Furthermore, the fauna under consideration is in some instances associated with specimens of *Lingula* and *Aviculipecten*. The living *Lingulas* sometimes inhabit brackish waters near the mouths of rivers, but never the fresh waters of lakes and streams, while the living *Pectinoids* are strictly marine. The fossil Pectinoids in question are small and depauperate examples and belong to a rather peculiar group, that of *Aviculipecten whitei*.

This assemblage can hardly be explained as due to the accidental commingling of types having different habitats. If it consisted of fresh-water animals washed out to sea we would expect to find the fresh-water types few and the marine ones numerous, varied, and characteristic. Such is not, however, the case. One would not a priori much expect to find marine animals washed into a fresh-water fauna, and in such an event we would probably look for an entire marine fauna, or, at least, granting that only a few specimens were washed in, that some such invaders would be of the usual marine types. Instead, the alien forms are always limited to one or two peculiar varieties. That abundant and differentiated marine life was always at hand waiting for an opportunity to migrate wherever the conditions became possible seems to be evidenced by the occurrence now and again of marine faunas in close association with beds of coal. On the whole, it seems most reasonable to regard this fauna as a natural assemblage of species selected and modified by a habitat, if not in strictly marine, at least not in strictly fresh waters.

There is another reputed occurrence of fresh-water forms in the Carboniferous, reported by Mr. Walcott from the Eureka district, of

Nevada. I have examined the fossils in question only casually, and it has been many years since I have seen them at all, but I doubt whether in this instance, any more than the other, the evidence warrants saying more than that they are possibly non-marine.

The Upper Carboniferous faunas of the West appear to be better differentiated than those east of the Rocky Mountains. At least three well-marked facies can be recognized. The oldest of these is found in the limestones whose occurrence has already been mentioned, resting directly upon Lower Mississippian limestones of similar character in Arizona and probably in Utah. This fauna is succeeded by one which is best considered from its development in the Transpecos region of Texas, because it is there more highly developed, more favorably studied, and more determinable in its stratigraphic relations with higher beds. It occurs in the Hueco formation which is 5,000 feet thick, and is practically calcareous throughout. As has already been noted, the Hueco formation by overlap rests upon the pre-Carboniferous in this region. The Mississippian faunas, together with the earlier Pennsylvanian ones, appear to be absent. The Hueconian fauna is widely distributed over the West, ranging indeed into Alaska, while it is even recognizable in Asia and eastern Europe. Most of the occurrences of Carboniferous in the West can be referred to this series, although some or them present more or less distinctive facies. The more important of the facies provisionally referred to the Hueconian are these: that of the Aubrey group of Arizona, rather widely distributed; that of the phosphate beds of the Preuss formation, local in Utah, Idaho, and Wyoming; the *Spiriferina pulchra* fauna with a considerable distribution in Idaho, Wyoming, Utah, and Arizona; the fauna of the McCloud limestone of California probably extending into Nevada; and that of the Nosoni formation of California (in part the "McCloud shale"), apparently recognizable to the eastward and to the North and West, even into Alaska.

In the Transpecos the beds of the Hueco formation are succeeded by those of the Guadalupe Mountains. The contact between the Hueco formation and the Guadalupian series is obscured by faulting and by desert deposits, but it is assumed that the interval between the highest known beds of the one and lowest known beds of the other is not a long one and that no unconformity exists between them. The

Guadalupian includes two formations, the Delaware Mountain formation and the Capitan limestone. The Delaware Mountain formation consists of sandstones and limestones, largely arenaceous to the North and largely calcareous to the South. The Capitan consists of whitish limestones and dolomites. Thus constituted the Guadalupian series is about 4,000 feet thick. The faunas of the two divisions of the Guadalupian are closely related to one another. They are very rich and varied, having already furnished over 325 species. The Guadalupian fauna is peculiar. But few of its species are common to the other American faunas and some of its genera, such as *Richthofenia*, *Leptodus*, *Geyerella* and *Aulosteges*, have not been noted elsewhere in the western hemisphere. Even the more common genera are in many cases represented by uncommon types. As an instance may be mentioned the genus *Composita* (*Seminula*), which, by the way, seems to be rather characteristic of our American faunas where it is ever present and ever abundant. In the Guadalupian this genus develops a bi-lobed species with a sinus on the dorsal as well as on the ventral valve and a deeply emarginated anterior border.

It is possible that the Guadalupian fauna may have an equivalent in California in the Robinson formation, in which I have noted a species of *Leptodus*, and a suggestion is contained in some forms from Nevada, but aside from this the Guadalupian facies is known only in a limited area in New Mexico and Texas.

It remains to speak of still another western fauna having a pronounced facies, a wide distribution, and a range through a considerable thickness of rocks. I mean the fauna of the so-called Permo-Carboniferous of the Wasatch Mountains, and the Permian of Mr. Walcott's Grand Canyon section. This fauna, which ranges also into Wyoming and Idaho, comprises little else than pelecypods, of which *Myalina* and *Aviculipecten* are the most common types, the Pectinoids being especially abundant and varied. It may tentatively be correlated with the Guadalupian (Delaware Mountain division), athough it presents but little resemblance to the Guadalupian fauna as at present known. At least, it appears to occupy a corresponding position in the section, resting upon strata which in the light of our present knowledge are correlated with the Hueco formation.

These western faunas are more easily correlated with those of

Europe, especially Russia, than with those much nearer geographically, in eastern North America. Indeed, the correspondence of our western faunas with those of Russia is truly remarkable. The Russian series consists, in ascending order, of the Mountain limestone, or *Productus giganteus* zone; the Moscovian, or "Lower Carboniferous;" the Gschelian or "Upper Carboniferous;" the Artinskian or "Permo-Carboniferous" and the Permian. One school of Russian geologists includes the Artinskian or Permo-Carboniferous beds in the Permian, and some Americans have followed them, but this seems to be of doubtful propriety. Murchison, DeVerneuil, and Keyserling mistook the Artinsk sandstone for the Millstone grit and distinctly excluded it from the Permian. If the faunal relations demand this extension of the term Permian to the Artinsk it would be justifiable, but such is not the case. At least, this appears to be the judgment of Tschernyschew, the chief of the Russian Survey, and other distinguished paleontologists at all events. In this recital the term Permian is used in exclusion of the Artinsk beds.

The *Productus giganteus* zone seems to be represented on this continent by the Baird shale of California whose fauna likewise contains *P. giganteus.*

The Moscovian, which has a facies very like our common Pennsylvanian faunas, may be compared with the earliest Pennsylvanian of Arizona and Utah, the term "Lower Carboniferous," as used by the Russians, having no relation to our own Lower Carboniferous or Mississippian. The Gschelian is clearly related to our Hueco formation, but with this zone the closeness of the analogy ceases. One is tempted to place in alignment the Artinsk and Permian which succeed the Gschelian in the Russian section, with the Delaware Mountain formation and Capitan limestone which succeed the Hueco formation in the American section, but such a correlation is neither sharply contradicted nor substantially supported by the faunal evidence. In fact, as exhibited in the literature, the faunas of the Artinsk and Permian are much less varied and individualized than those of the Guadalupian. The following suggestions are made with the diffidence of second-hand and imperfect knowledge, but it would appear that after the Gschelian stage there was in the Russian area a gradual progression from marine to at least near-shore conditions. This seems to be indicated by the great reduction in the marine facies, especially in the brachiopod representation, so that in the Permian there remains scarcely a tithe of the greatly diversified brachiopod fauna of the Gschelian, and by the introduction of fresh-water types of which not less than 200 species have been recognized. Apparently the typical Permian deposits of Russia represent local and not normally marine conditions of deposition.

I am tentatively assuming, on the grounds noted above, that the Guadalupian is equivalent to the Permian or to the Permian and Artinskian, the one representing a normal marine and the other an abnormal facies. It may prove, however, that all or part of the Guadalupian is younger than the Permian. A recent monograph by Tschernyschew gives a complete account of the brachiopods of the Gschelian, but the other types remain undescribed or else the descriptions are badly scattered. The literature on the Artinskian and Permian is also somewhat scattered, but one receives the impression that the brachiopods of the latter do not present many positive differences from those of the Gschelian though much less varied, and reduced to a few types of long range and wide distribution. Whether the same is true of the rest of the fauna it is difficult to say, although it seems rather doubtful. In view of the striking difference between the faunas of the Guadalupian and the Hueco formation, in which the brachiopods are most in point, of a lack of a corresponding difference between the Gschelian and Permian, of the marked resemblance of the brachiopods of the Hueco and Gschelian, and of the lack of agreement between the Permian and Guadalupian, there is a possibility, if not a certain probability, that the Artinsk and Permian may be correlated with the Hueco formation.

Having compared the western faunas with those of Russia, let us consider what their relations may be with those of eastern North America.

We find in such a comparison really fewer resemblances than with the faunas of Russia. Of the three or four western faunas which I have noted, by far the greatest resemblance is to be found in the oldest of all; perhaps because it is least varied and most generalized. The Hueconian presents much more numerous and extensive differences and the Guadalupian the strongest of all. In fact, of the 325 species recognized in the latter scarcely a single variety can be definitely identified in the eastern faunas. The species are in most cases not only not the same but they are not even similar. It seems possible to me that the Hueconian fauna may be equivalent, in spite of its differences, to the faunas of the East, but hardly that of the Guadalupian. This opinion is based upon the striking differences existing between the Guadalupian and any eastern fauna, upon the much closer resemblance of the eastern faunas with the Hueconian fauna, and upon the important differences between the latter and the Guadalupian. However, as so little is known of the character and potency of the environmental conditions under which these faunas existed, there is a possibility which I do not wish to deny that the relations noted may have to be ascribed to the environment element, rather than to the time element.

Provisionally I am regarding the Guadalupian as younger than any known faunas of the eastern region, thus interpreting the faunal differences of the Hueconian when compared with the Pennsylvanian and Permian of the East, as due to environment rather than to time. There is some evidence, however, that the Hueco formation should be considered younger than the so-called Permian of the Kansas section instead of equivalent to it. Mr. Beede has recently described several occurrences of a fauna which I should perhaps have mentioned as representing one of the interesting and important differentiations found among the faunas of the Upper Carboniferous of the East. They were obtained from the red beds of Oklahoma and the horizon is known to be considerably above the highest occurrences of invertebrate fossils in Kansas. This fauna appears to me to present more important differences from the Kansas Permian than exist between the latter and the underlying beds referred to the Pennsylvanian. Accordingly, if any of the faunas of the eastern section are to be classed as Permian it would appear to me more appropriate that the dividing line should pass above rather than below the Kansas Permian. When compared with the western faunas, that described by Mr. Beede is far from being identical either with the Guadalupian or with any facies of the Hueconian, but of the two its affinities appear to be decidedly with the latter. If this evidence is to be relied on, even Mr. Beede's fauna is older than the Guadalupian and if the latter is equivalent to the Permian, older than the Permian.

Another fact which might be brought forward to support the contention that even the Hueconian is younger than the Kansas Permian is the important unconformity which preceded Hueco sedimentation and was accompanied by a corresponding change in the subsequent fauna. According to this interpretation, the oldest of the western faunas, which, as already noted, presents a closer resemblance to the characteristic Pennsylvanian fauna than any other, would correlate with all of the eastern section to the top of the Kansas Permian. Its failure in the strata which it occupies to measure up to the thickness of the Mississippi Valley section, and the absence from it of some of the modifications found there, would be ascribed to pre-Hueconian erosion. After this episode there was, it might be claimed, a faunal change represented in the Hueconian fauna of the West and in Mr. Beede's red beds fauna of Oklahoma, this in turn being succeeded by the Guadalupian fauna.

Though keeping this interpretation of the facts well in mind, I am at present adopting the more conservative hypothesis—that the top of the Kansas Permian may be as high as the base of the Guadalupian; but that no part of the latter correlates with any part of the invertebrate-bearing beds of Kansas.[1] From this it would follow that if the Guadalupian is equivalent to the Russian Permian then the Kansas Permian is distinctly older, possibly Artinskian, possibly Gschelian. If, on the other hand, the Kansas Permian is really equivalent to that of Russia, the Guadalupian would appear to be a distinct and faunally well characterized series younger than the Permian.

It is well in considering the use of the word Permian for North American strata to discriminate Permian time, Permian conditions, and Permian faunas. Permian conditions, or conditions such as were prevalent in Russia during Permian time, might recur more than once. Indeed, it is safe to say that most conditions are repeated in one area or another many times during geologic history. Permian conditions would give character to the sediments and to the faunas of Permian time. But, while the same peculiarities of sedimentation would presumably be manifested at every recurrence of Permian conditions, the character of the fauna would be partially determined by another factor, the biologic factor. It is conceivable, or even probable, that similar conditions acting upon two unlike faunas might produce rather similar results. The resulting faunas might be less diverse than the original ones. This is perhaps particularly true of conditions such as appear to have prevailed in the typical Permian, conditions hostile to marine life, hostile especially to the continuance of specialized types of life, at least of brachiopods.

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[1] By this expression I mean to include the Marion and subjacent formations.

In the Kansas section we appear to have a single faunal sequence gradually passing to extinction but undergoing some minor modifications in the process. The upper portion of the sequence is the Kansas Permian. We are told by those who are familiar with both, that Permian conditions are manifested in the so-called Permian sediments of the Mississippi Valley. I believe that there is no strictly Permian fauna in that area. The question at issue is: Do the higher invertebrate-bearing beds of the Kansas section represent Permian time? On the assumption that such is the case, a comparison of the evolution of the faunas of the two continents is interesting. Let any one acquainted with our eastern faunas look over Trautschold's monograph on the Moscovian fauna and he would exclaim at once, "This is our Pennsylvanian facies." Let him next examine Tschernyschew's monograph on the Gschelian brachiopods, and he would find that nothing at all comparable is known among the faunas of eastern North America. He would even find that the few Pennsylvanian species which Tschernyschew has recognized among the Gschelian brachiopods are wrongly identified. If he furthermore studies the scattered accounts of the Artinskian and Permian faunas I think, too, that he will find less resemblance between them and the Kansas Permian than has often been supposed.

Apparently there was a basal generalized type of Upper Carboniferous fauna distributed over both continents without any wide difference of facies—the Moscovian of Russia, the pre-Hueconian of western North America, and the early Pennsylvanian of eastern. Then changes occurred which brought about striking and similar modification in the faunas of western America and Russia, the Gschelian of Russia and the Hueconian of western North America. Then again other changes occurred which brought about a third modification, this time restricted to western America, or, at all events, not developed similarly there and in Russia. Meanwhile the fauna of eastern North America must have remained essentially static until similar conditions, setting in in Perm and in Kansas, eventually extinguished those already moribund faunas, while the intervening faunas, those of western America, remained vigorous and rich. The considerable differences found between the Russian Permian and the Kansas Permian faunas would, according to this hypothesis, be explained as due to the play of like conditions upon unlike organic bases, the pre-Permian faunas in the one region having changed, and those in the other having remained unchanged. But this appears to me improbable. One would hardly expect that the Pennsylvanian fauna would remain static during so long a period in which such important faunal changes were taking place in adjacent areas. Nor would one expect that Permian conditions would be inaugurated simultaneously in two areas so far apart, whose biologic histories are so different, and which were separated by an area having a more or less independent set of faunal phenomena. Finally, if the Kansas Permian is Permian, what is the fauna from the Oklahoma red beds, obtained at a considerably higher horizon, and showing a considerably different facies? It does not seem probable to me therefore that the Kansas Permian and the Russian Permian were contemporaneous.

An extreme interpretation of the resemblances and differences noted in comparing the successive faunas of Russia and eastern North America would result in correlating the Kansas Permian not with the Russian Permian, as in the last hypothesis, but with the Moscovian. In this case the quasi-Permian facies of the upper beds of Kansas would be accounted for as showing the yield of an unlike and older fauna to Permian conditions which arrived on this continent at a much earlier period than in Russia, just as in the previous case the *differences* of the same fauna from the typical Permian would be explained as the opposite or complementary phenomenon, the resistance of an unlike fauna to Permian conditions. Probably the ultimate fact lies somewhere between these two extreme interpretations of the evidence.

I do not wish to appear as having a rooted aversion to admitting the Permian age of the higher faunas of the Kansas section. My position is merely that of a skeptic and the only point upon which I feel justified in assuming the positive attitude of dogmatism is that the evidence at present is so inconclusive that dogmatism itself would be ill-advised. At present, it is true, the weight of evidence, as presented by invertebrate paleontology, appears to me to be in favor of its pre-Permian age. This view has much of precedent against it, although it has considerable authority in its support. It will be remembered that some half century ago there was a conscious and competitive attempt between a number of invertebrate paleontologists to discover the presence of Permian rocks in our then western states. From this the correlation of the Kansas beds with the Russian Permian took its rise. I am inclined to believe that were the investigation of this subject taken up on its merits from the richer accumulations now available, and not compromised by this early rivalry, few if any would think of separating the upper formations of the series from the lower, or, if a separation were thought of, the divisions would be held rather to rank with the subdivisions recognized in the Mississippian than co-ordinate with the larger groups such Mississippian and Pennsylvanian.

At all events, it appears to me from such evidence as I have seen, that the Russian Permian represents peculiar, one may perhaps say abnormal, conditions which were probably local or regional in extent. That Permian time is represented by our sediments seems undoubted; that Permian conditions prevailed here is attested by good witnesses; that Permian conditions occurred here in Permian time seems to me open to question, and that any of our known faunas present the authentic Permian facies, I do not believe. Consequently the propriety of employing the term Permian in the geology of North America seems to me decidedly doubtful, at least in so far as the evidence of invertebrate fossils is concerned. It would be better, I believe, to use the term Permian wherever the Permian fauna can be traced and no farther; to use the term Pennsylvanian wherever the Pennsylvanian fauna can be traced and no farther; to use the term Guadalupian wherever the Guadalupian fauna can be traced and no farther; but, if, for instance, it could be shown that for all their faunal differences the Gschelian and Pennsylvanian were contemporaneous, to use for both the same name, whether Pennsylvanian or Gschelian, would be to obscure and gloss over facts of biology, climatology, and possibly geography, fully as important as that of chronology.